EFFECTS OF MICROWAVES ON *PERIPLANETA AMERICANA* AND *TRIBOLIUM CONFUSUM*

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The cockroach, Periplaneta americana *L. and the confused flour beetle,* Tribolium confusum *Duv. can be killed by low-level microwave power radiation at a frequency of 2,450 megacycles (mcs) with electric field strengths less than 65 volts per cm (V/cm) in a plane wave transmission system, as well as in multimode resonant cavities (electronic ovens) supplied with 1 or 2 kilowatts (kw) of power. The lethal effect of radiation at this frequency is mainly due to heat. In* P. americana, *localised internal molecular heating occurs, due to the size of the insect. With the smaller* T. confusum, *direct heating of the insect does not appear to be a predominant factor but it is shown that these insects can be killed in large volumes of flour, with microwave power used to raise the temperature of the material. However, the exposure time required depends on the insect's size in relation to the wavelength. Effects on the activity of both species were observed and adverse effects on reproduction are established with* T. confusum *adults.*

INTRODUCTION

Frings (1952), and Whitney *et al.* (1961) have discussed the effectiveness of radio frequency electromagnetic waves in killing certain insect species. Their results show that the mortality is predominantly a thermal effect, energy being absorbed by the insects in preference to surrounding media such as flour and grain. Reproduction was not affected in those specimens that survived the treatment (Whitney *et al.*, 1961).

This investigation was made to determine the effectiveness of far higher frequencies, in the radar range (2,450 mcs), at comparable incident power levels (0.5 to 2.0 kw) on the cockroach *Periplaneta americana* L. and the confused flour beetle, *Tribolium confusum* Duv.

The generation and transmission of microwave power has been described by Okress *et al.* (1964). The energy transfer systems and the thermal effects in relation to the properties of heating dielectrics have been discussed by Copson (1962) and Voss (1965). For the work described here, microwave power was generated at 2,450 mcs by a 2 kw magnetron used to power a plane wave transmission system 72 cm wide, the metal plates of which were separated by 5 cm in the direction of the electric field. In the latter case, the power density was variable between 1.25 and 5 w/cm^2, measured by a calibrated power meter on the coupling system to the magnetron. A power density of 5 w/cm^2 corresponds to an average transverse field strength of 65 V/cm in the transmission system.

Insect and environment temperatures were measured with a needle-point iron-constantan thermocouple referenced against melting ice. Standard rearing techniques were used for both insect species.

RESULTS

P. americana L.

Female roaches were placed individually in small enclosures drilled in non power absorbent plastic foam blocks in petri dishes, and treated in the plane wave transmission system. Various exposure times and power densities were used. After exposure, the internal body temperature was recorded in three places. Insects that survived the exposure were kept in glass observation jars and supplied with food.

It was found that an incident power density of 1.25 w/cm^2 kills the insects in 90 seconds after which the average body temperature was 60^{o}C; a power level of 5 w/cm^2 kills the insects in 5 seconds with a body temperature of 72^{o}C. Halving the above exposure times caused the insects to be knocked down and they died within three to five days. The minimum body temperature recorded for a specimen which died at once was 37^{o}C , after treatment with 2.5 w/cm^2 for fifteen seconds. About 60 roaches were used in these tests. Roaches heated in a conventional oven (at 60^o C for seven minutes) survived and behaved normally (average body temperature 38^o C). After twenty minutes in the same oven death resulted, with a body temperature of 41^o C.

Although the above results are not completely determinant, it is postulated that either localised heating or other physiological changes occur within the insect at low energy densities. The problem is particularly complex as an unknown proportion of the power density incident on the insect is transmitted through it. The known behaviour of dielectrics containing water suggests that the transmitted power would increase with dielectric (insect) temperature. Further, it was found that legless specimens heat more slowly than normal ones, whereas the relative orientation of the body to the electric field had no observable effect.

T. confusum Duv.

Different developmental stages of the confused flour beetle were treated in a carefully designed 48.5 x 40 x 38.5 cm multimode cavity, excited by a magnetron at 2,450 mcs. In one test, 1.2 kw of power was supplied to ten pounds of flour in the cavity, in which different stages of the insect were confined to specimen tubes distributed uniformly throughout the volume. After 2.5 minutes a fairly uniform temperature of the flour was recorded at 42^{o}C (ambient 25^{o}C). Mortality rates were zero. The same procedure was followed using 25 pounds of flour. The temperatures were recorded as 32^{o}C (uniform) after 2 minutes, 45-75^o C and 55-90^{o}C after 4.5 and 7 minutes respectively, the variation of temperature being due to non-uniform heating in still flour, caused by variations in the electric field strength and moisture content (average value 12%). Specimens were removed from various areas at the times indicated. After the 4.5 minute interval, some insects survived in the lower temperature zones, all others were killed. Further tests indicated that the reproduction of *T. confusum* was affected by this treatment. In one test designed specifically to investigate this, a large number of insects, lightly covered with flour were exposed to 1.2 kw in the cavity system for 4 minutes. The initial mortality was zero but 90% failed to reproduce.

DISCUSSION

In view of the technical feasibility of generating high levels of microwave power at low cost, the method may prove to be economically feasible for sterilizing flour infested with *T. confusum* and may have other applications. Of more fundamental interest is the possibility of isolating the thermal and physiological effects induced by high frequency electric fields using the techniques described in this paper.

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REFERENCES

Copson, D., 1962. Microwave Heating, Avi Publ. Co. Westport, Conn.

Frings, H., 1952. Factors determining the effects of radio frequency electromagnetic fields on insects and materials they infest. J. econ. Ent., 45 : 396-408.

Okress, E.C. *et al.*, 1964. Microwave Power Engineering, Spectrum 1, No. 10, 76-100.

Voss, W.A.G., 1965. Factors affecting the operation of high power microwave heating systems for lumber processing. Institution of Electrical and Electronic Engineers, 7th Biennial Electric Heating Conference, Cleveland, Ohio.

Whitney, W.K., Nelson, S.O. and Walkden, H.H., 1961. Effects of high frequency electric fields on certain species of stored grain insects, U.S.D.A. Marketing Res. Rep. 455. pp. 1-52.